# 1ST CHAPTER

# CONCRETE AS A CONSTRUCTION MATERIAL

**Definition of concrete:**

Concrete is the most commonly used man-made material on earth. It is an important construction material used extensively in buildings, bridges, roads and dams. Its uses range from structural applications, to kerbs, pipes and drains.

**Concrete is a mixture of binding material, aggregates and water in a definateproportion**.

**1. Types of concrete:**

1. Cement concrete: It is a mixture of cement, fine aggregates, coarse aggregates and water in a definite proportion.

2. Lime concrete: Here binding material is lime (CaO)

3: RCC: Steel reinforcing is done in the Cement Concrete. 4:
Prestressed cement concrete:

This concrete is a form of concrete used in construction which is "pre-stressed" by being placed under compression prior to supporting any loads beyond its own dead weight. This compression is produced by the tensioning of high-strength "tendons" located within or adjacent to the concrete volume, and is done to improve theperformance of the concrete in service.

**2. Uses of concrete:**

Many structural elements like footings, columns, beams, chejjas, lintels, roofs are made with R.C.C. Cement concrete is used for making storage structures like water tanks, bins, silos, bunkers etc. Bridges, dams, retaining walls are R.C.C. structuresin which

concrete is the major ingradientin storage structures like water tanks, bins, silos, bunkers etc.

1. It is a relatively cheap material and has a relatively long life with few maintenance requirements.

2. It is strong in compression.

3. Before it hardens it is a very pliable substance that can easily be shaped.

4. It is non-combustible.

**4. Limitations of concrete:**

The limitations of concrete include:

1. Relatively low tensile strength when compared to other building materials.

2. Low ductility.

3. Low strength-to-weight ratio.

4. It is susceptible to cracking.

# 2nd CHAPTER
# CEMENT

cement is a binding material used in the masonry.
Physical Properties of Cement

Different blends of cement used in construction are characterized by their physical properties.

Some key parameters control the quality of cement. The physical properties of good cement are based on:

A. Fineness of cement
B. Soundness
C. Consistency
D. Strength
E. Setting time
F. Heat of hydration
G. Loss of ignition
H. Bulk density

Specific gravity (Relative density) These physical properties are discussed in details in the following segment. Also, you will find the test names associated with these physical properties.

1. Fineness of Cement

The size of the particles of the cement is its fineness. The required fineness of good cement is achieved through grinding the clinker in the last step of cement production process. As hydration rate of cement is directly related to the cement particle size, fineness of cement is very important.

2. Soundness of Cement

refers to the ability of cement to not shrink upon hardening. Good quality cement retains its volume after setting without delayed expansion, which is caused by excessive free lime and magnesia.

Tests: Unsoundness of cement may appear after several years, so tests for ensuring soundness mustbe able to

determine that potential.

2.1 Le Chatelier Test

This method, done by using Le Chatelier Apparatus, tests the expansion of cement due to lime. Cement paste (normal consistency) is taken between glass slides and submerged in water for 24 hours at 20+1°C. It is taken out to measure the distance between the indicators and then returned under water, brought to boil in 25-30 mins and boiled for an hour. After cooling the device, the distance between indicator points is measured again. In a good quality cement, the distance shouldnot exceed 10 mm.

3. Consistency of Cement

The ability of cement paste to flow is consistency. It is measured by Vicat Test. In Vicat Test Cement paste of normal consistency is taken in the Vicat Apparatus. The plunger of the apparatus is brought down to touch the top surface of the cement. The plunger will penetrate the cement up to a certaindepth depending on the consistency. A cement is said to have a normal consistency when the plunger penetrates 10±1 mm.

4. Strength of cement

Three types of strength of cement are measured – compressive, tensile and flexural. Various factorsaffect the strength, such as water-cement ratio, cement-fine aggregate ratio, curing conditions, size and shape of a specimen, the manner of molding and mixing, loading conditions and age. While testing the strength, the following should be considered: Cement mortar strength and cement concrete strength are not directly related. Cement strength is merely a quality control measure. The tests of strength are performed on cement mortar mix, not on cement paste. Cement gains strength over time, so the specific time of performing the test should be mentioned.

5. Compressive Strength

It is the most common strength test. A test specimen (50mm) is taken and subjected to a compressive load until failure. The loading sequence must be within 20 seconds and 80 seconds. Tensile strength Though this test used to be common during the early years of cement production, now it does not offer any useful information about the properties of cement.

Flexural strength

This is actually a measure of tensile strength in bending. The test is performed in a 40 x40 x 160 mmcement mortar beam, which is loaded at its center point until failure.Standard test: ASTM C 348: Flexural Strength of Hydraulic Cement Mortars

2. Setting Time of Cement

Cement sets and hardens when water is added. This setting time can vary depending on multiple factors, such as fineness of cement, cement-water ratio, chemical content, and admixtures. Cementused in construction should have an initial setting time that is not too low and a final setting time not too high. Hence, two setting times are measured:

Initial set: When the paste begins to stiffen noticeably (typically occurs within 30-45 minutes) Final set: When the cement hardens, being able to sustain some load (occurs below 10 hours) Again, setting time can also be an indicator of hydration rate.

Standard Tests:

AASHTO T 131 and ASTM C 191: Time of Setting of Hydraulic Cement by Vicat Needle AASHTO T 154:Time of Setting of

Hydraulic Cement by Gillmore Needles

ASTM C 266: Time of Setting of Hydraulic-Cement Paste by Gillmore Needles

3. Heat of Hydration

When water is added to cement, the reaction that takes place is called hydration. Hydration generates heat, which can affect the quality of the cement and also be beneficial in maintaining curing temperature during cold weather. On the other hand, when heat generation is high, especially in large structures, it may cause undesired stress. The heat of hydration is affected most by C3S and C3A present in cement, and also by water-cement ratio, fineness and curing temperature. The heat of hydration of Portland cement is calculated by determining the difference between the dry and the partially hydrated cement (obtained by comparing these at 7th and 28th days).

Standard Test: ASTM C 186: Heat of Hydration of Hydraulic Cement

4. Loss of Ignition

Heating a cement sample at 900 - 1000°C (that is, until a constant weight is obtained) causes weight loss. This loss of weight upon heating is calculated as loss of ignition. Improper and prolonged storage or adulteration during transport or transfer may lead to pre-hydration and carbonation, bothof which might be indicated by increased loss of ignition.

Standard Test: AASHTO T 105 and ASTM C 114: Chemical Analysis of Hydraulic Cement

5. Bulk density

When cement is mixed with water, the water replaces areas where there would normally be air. Because of that, the bulk density of cement is not very important. Cement has a varying range of density depending on the cement composition percentage. The density of cement may be anywherefrom 62 to 78 pounds per cubic foot.

6. Specific Gravity (Relative Density)

Specific gravity is generally used in mixture proportioning calculations. Portland cement has a specific gravity of 3.15, but other types of cement (for example, portland-blast-furnace-slag andportlandpozzolan cement) may have specific gravities of about 2.90.

Standard Test: AASHTO T 133 and ASTM C 188: Density of Hydraulic Cement

**B. Chemical Properties of Cement**

The raw materials for cement production are limestone (calcium), sand or clay (silicon), bauxite (aluminum) and iron ore, and may include shells, chalk, marl, shale, clay, blast furnace slag, slate. Chemical analysis of cement raw materials provides insight into the chemical properties of cement.1 Tricalcium aluminate (C3A)

Low content of C3A makes the cement sulfate-resistant. Gypsum reduces the hydration of C3A,which

liberates a lot of heat in the early stages of hydration. C3A does not provide any more than a littleamount of strength.

Type I cement: contains up to 3.5% $SO_3$ (in cement having more than 8% C3A)
Type IIcement: contains up to 3% $SO_3$ (in cement having less than 8% C3A)

2. Tricalcium silicate (C3S)

C3S causes rapid hydration as well as hardening and is responsible for the cement's early

strength gain an initial setting.

3. Dicalcium silicate (C2S)

As opposed to tricalcium silicate, which helps early strength gain, dicalcium silicate in cement helpsthe strength gain after one week.

4. Ferrite (C4AF)

Ferrite is a fluxing agent. It reduces the melting temperature of the raw materials in the kiln from 3,000°F to 2,600°F. Though it hydrates rapidly, it does not contribute much to the strength of thecement.

5. Magnesia (MgO)

The manufacturing process of Portland cement uses magnesia as a raw material in dry process plants. An excess amount of magnesia may make the cement unsound and expansive, but a little amount of it can add strength to the cement. Production of MgO-based cement also causes less $CO_2$emission. All cement is limited to a content of 6% MgO.

6. Sulphur trioxide

Sulfur trioxide in excess amount can make cement unsound.

7. Iron oxide/ Ferric oxide

Aside from adding strength and hardness, iron oxide or ferric oxide is mainly responsible for thecolor of the cement.

8. Alkalis

The amounts of potassium oxide (K2O) and sodium oxide (Na2O) determine the alkali content of the cement. Cement containing large amounts of alkali can cause some difficulty in regulating the settingtime of cement. Low alkali cement, when used with calcium chloride in concrete, can cause discoloration. In slag-lime cement, ground granulated blast furnace slag is not hydraulic on its own but is "activated" by addition of alkalis. There is an optional limit in total alkali content of 0.60%, calculated by the equation Na2O + 0.658 K2O.

9. Free lime

Free lime, which is sometimes present in cement, may cause expansion.

10. Silica fumes

Silica fume is added to cement concrete in order to improve a variety of properties, especially compressive strength, abrasion resistance and bond strength. Though setting time is prolonged by the addition of silica fume, it can grant exceptionally high strength. Hence, Portland cement containing 5- 20% silica fume is usually produced for Portland cement projects that require highstrength.

11. 11.

Cement containing high alumina has the ability to withstand frigid temperatures since alumina ischemical-resistant. It also quickens the setting but weakens the cement.

**Aggregates:**

Aggregates are the important constituents of the concrete which give body to the concrete and also reduce shrinkage. Aggregates occupy 70 to 80 % of total volume of concrete. So, we can say that one should know definitely about the aggregates in depth to study more about concrete.

**Classification of Aggregates as per Size and Shape**

Aggregates are classified based on so many considerations, but here we are going to discuss about their shape and size classifications in detail.

**Classification of Aggregates Based on Shape**

We know that aggregate is derived from naturally occurring rocks by blasting or crushing etc., so, it is difficult to attain required shape of aggregate. But, the shape of aggregate will affect the workability of concrete. So, we should take care about the shape of aggregate. This care is not only applicable toparent rock but also to the crushing machine used.

Rounded aggregates

- o Irregular or partly rounded aggregates
- o Angular aggregates
- o Flaky aggregates
- o Elongated aggregates
- o Flaky and elongated aggregates

**Rounded Aggregate**

The rounded aggregates are completely shaped by attrition and available in the form of seashore gravel. Rounded aggregates result the minimum percentage of voids (32 – 33%) hence gives more workability. They require lesser amount of water-cement ratio. They are not considered for high strength concrete because of poor interlocking behavior and weak bond strength

**Irregular Aggregates**

The irregular or partly rounded aggregates are partly shaped by attrition and these are available in the form of pit sands and gravel. Irregular aggregates may result 35- 37% of voids. These will give lesser workability when compared to rounded aggregates. The bond strength is slightly higher than rounded aggregates but not as required for high strength concrete

**Angular Aggregates**

The angular aggregates consist well defined edges formed at the intersection of roughly planar surfaces and these are obtained by crushing the rocks.Angular aggregates result maximum percentage of voids (38-45%) hence gives less workability. They give 10-20% more compressive strength due to development of stronger aggregate-mortar bond. So,

these are useful in high strength concrete manufacturing.

**Flaky Aggregates**

When the aggregate thickness is small when compared with width and length of that aggregate it is said to be flaky aggregate. Or in the other, when the least dimension of aggregate is less than the 60% of its mean dimension then it is said to be flaky aggregates.

**Flaky and Elongated Aggregates**

When the aggregate length is larger than its width and width is larger than its thickness then it is said to be flaky and elongated aggregates. The above 3 types of aggregates are not suitable for concrete mixing. These are generally obtained from the poorly crushed rocks.

**Classification of Aggregates Based on Size**

Aggregates are available in nature in different sizes. The size of aggregate used may be related to themix proportions, type of work etc. the size distribution of aggregates is called grading of aggregates. Following are the classification of aggregates based on size:

**Aggregates are classified into 2 types according to size**

*o* Fine aggregate

*o* Coarse aggregate

**Fine Aggregate**

When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate, silt and clay are also come under this category. The soft deposit consisting of sand, silt and clay is termed as loam. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

**Fine aggregate Size variation**
Coarse Sand 2.0mm – 0.5mm
Medium sand 0.5mm – 0.25mm
Fine sand 0.25mm – 0.06mm

Silt 0.06mm – 0.002mm
Clay <0.002

**Coarse Aggregate**

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. the size range of various coarse aggregates given below.

**Coarse aggregate Size** Fine gravel 4mm – 8mm Medium gravel 8mm – 16mmCoarse gravel 16mm – 64mm Cobbles 64mm – 256mm Boulders >256mm

**Bulking of Sand**

The increase in moisture of sand increases the volume of sand. The reason is that moisture causes film of water around sand particles which results in the increase of volume of sand. For a moisturecontent percentage of 5 to 8 there will be an increase in volume up to 20 to 40 percent dependingupon sand. If the sand is finer there will be more increase in volume. This is known as bulking of sand.Graphical representation of bulking of sand is shown below.

When the moisture content of sand is increased by adding more water, the sand particles pack neareach other and the

amount of **bulking of sand** is decreased. Thus, it helps in determining the actual volume of sand, the dry sand and the sand completely filled with water will have the exact volume. The volumetric proportioning of sand is greatly affected by bulking of sand to a greater extent. The affected volume will be great for fine sand and will be less for coarse sand. If proper allowance is not made for the bulking of sand, the cost of concrete and mortar increases and it results into under-sanded mixes which are harsh and difficult for working and placing.

**i)** To measure the strength or quality of the material ii) To determine the water absorption of aggregates

**APPARATUS:**

The apparatus consists of the following

(a) A balance of capacity about 3kg, to weigh accurate 0.5g, and of such a type and shape as topermit weighing of the sample container when suspended in water.

(b) A thermostatically controlled oven to maintain temperature at 100-110° C.

(c) A wire basket of not more than 6.3 mm mesh or a perforated container of convenient size with thin wire hangers for suspending it from the balance. (d) A container for filling water and suspendingthe basket

(e) An air tight container of capacity similar to that of the basket

(f) A shallow tray and two absorbent clothes, each not less than 75x45cm.

**THEORY:**

The specific gravity of an aggregate is considered to be a measure of strength or quality of the material. Stones having low specific gravity are generally weaker than those with higher specificgravity values.

**PROCEDURE:**

(i) About 2 kg of aggregate sample is washed thoroughly to remove fines, drained and placed in wirebasket and immersed in distilled water at a temperature between 22- 32º C and a cover of at least 5cm of water above the top of basket.

(ii) Immediately after immersion the entrapped air is removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop at the rate of about one drop per second. The basket and aggregate should remain completely immersed in water for a period of 24 hour afterwards.

(iii) The basket and the sample are weighed while suspended in water at a temperature of 22° –

32°C. The weight while suspended in water is noted =W1g.

(iv) The basket and aggregates are removed from water

(iv) The basket and aggregates are removed from water and allowed to drain for a few minutes, afterwhich the aggregates are transferred to the dry absorbent clothes. The empty basket is then returned to the tank of water jolted 25 times and weighed in water=W2g. .

(v) The aggregates placed on the absorbent clothes are surface dried till no further moisture could be removed by this cloth. Then the aggregates are transferred to the second dry cloth spread in single layer and allowed to dry for at least 10 minutes until the aggregates are completely surface dry. The

surface dried aggregate is then weighed =W3 g

(vi) The aggregate is placed in a shallow tray and kept in an oven maintained at a temperature of110° C for 24 hrs. It is then removed from the oven, cooled in an air tight container and weighted=W4 g.

Specific gravity = (dry weight of the aggregate /Weight of equal volume of water)

(1) Apparent specific gravity = (dry weight of the aggregate/Weight of equal volume of waterexcluding air voids in aggregate)

**OBSERVATIONS**

Weight of saturated aggregate suspended in water with basket = W1 g Weight of basket suspendedin water = W2 g Weight of saturated aggregate in water = W1 – W2 g Weight of saturated surface dry aggregate inair = W3 g Weight of water equal to the volume of the aggregate = W3–(W1–W2)g Weight of oven dryaggregate = W4 g

(1) Specific gravity = W3 / (W3– (W1– W2))

(2) Apparent specific gravity = W4 / (W4– (W1– W2))

(3) Water Absorption = ((W3 – W4) / W4) X 100

**RESULT:**

(1) Specific gravity =

(2) Apparent specific gravity = (3)
Water Absorption =

**RECOMMENDED VALUE:** The size of the aggregate and whether it has been artificially heated should be indicated. ISI specifies three methods of testing for the determination of the specific gravity of aggregates, according to the size of the aggregates. The three size ranges used are aggregates larger than 10 mm, 40 mm and smaller than 10 mm. The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Though high specific gravity is considered as an indication of high strength, it is not possible to judge the suitability of a sample road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values. absorption shall not be more than 0.6 per unit by weight

**Water Cement Ratio**
**Hydration of Cement**
**Introduction**

Portland cement is a hydraulic cement; hence it derives its strength from chemical reactionsbetween the cement and water. The process is known as hydration.

Cement consists of the following major compounds (see composition of cement):

- Tricalcium silicate, C3S
- Dicalcium silicate, C2S
- Tricalcium aluminate, C3A
- Tetra calcium alumina ferrite, C4AF
- Gypsum, CSH2 Water–cement Water–cement ratio

The **water–cement ratio** is the ratio of the weight of water to the weight of cement used in a concrete mix. A lower ratio leads to higher strength and durability, but may make the mix difficult to work with and form. Workability can be resolved with the use of plasticizers or super-plasticizers.

Often, the ratio refers to the ratio of water to cement plus pozzolan ratio, w/(c+p). The pozzolan is typically a fly ash, or blast furnace slag. It can include a number of other materials, such as silica fume, rice husk ash or natural pozzolans. Pozzolans can be added to strengthen concrete.

Duff Abrams' law. The notion of water–cement ratio was first developed by Duff A. Abrams and published in 1918.

Concrete hardens as a result of the chemical reaction between cement and water (known as hydration, this produces heat and is called the heat of hydration). For every pound (or kilogram or any unit of weight) of cement, about 0.35 pounds (or 0.35 kg or corresponding unit) of water is needed to fully complete hydration reactions. However, a mix with a ratio of 0.35 may not mix thoroughly, and may not flow well enough to be placed. More water is therefore used than is technically necessary to react with cement. Water–cement ratios of 0.45 to 0.60 are more typically used. For higher-strength concrete, lower ratios are used, along with a plasticizer to increase flowability. Too much water will result in segregation of the sand and aggregate components from the cement paste

**Effect of Water Cement Ratio on Strength of Concrete:**

The water-cement ratio is one of the most important aspect when it comes to maintaining the strength of Concrete. The ratio depends on the grade of concrete and the structure size. We generally prefer a W/C ratio of 0.4 to 0.6, but it can be decreased in case of high-grade concrete, we reduce the amount of water and use plasticizers instead. W/C ratio affects the workability of concrete and thus should be taken into careful consideration. Also, if the ratio exceeds the normal value, segregation of concrete occurs and the coarse aggregate settles at the bottom, thus affecting the strength of concrete greatly.

**Limitation of Water Cement Law:**

1. The internal moisture condition of hydration of cement continues till the concrete gain full strength.

2. The concrete specimen is cured under standard temperatures.

3. The concrete specimens should of same size.

4. The concrete specimens should of same age.

**Workability**

Workability is defined as the amount of energy required to overcome internal friction and cause complete compaction.

Workability is completely depending upon the properties of various ingredients of concrete.

**Factors Affecting Workability**

-Cement content of concrete Water content of concrete Mix proportions of concrete Size of

- aggregates
- Shape of aggregates
- Grading of aggregates
- Surface texture of aggregates
- Use of admixtures in concrete
- Use of supplementary cementitious materials

**Following are the general factors affecting concrete workability:**

**1. Cement Content of Concrete**

Cement content affects the workability of concrete in good measure. More the quantity of cement, the more will be the paste available to coat the surface of aggregates and fill the voids between them. This will help to reduce the friction between aggregates and smooth movement of aggregates during mixing, transporting, placing and compacting of concrete. Also, for a given water-cement ratio, the increase in the cement content will also increase the water content per unit volume of concrete increasing the workability of concrete. Thus, increase in cement content of concrete also increases the workability of concrete.

**2. Type and Composition of Cement**

There are also affect of type of cement or characteristics of cement on the workability of concrete. The cement with increase in fineness will require more water for same workability than the comparatively less fine cement. The water demand increased for cement with high $Al_2O_3$ or $C_2S$ contents.

**3. Water/Cement Ratio or Water Content of Concrete**

Water/cement ratio is one of the most important factors which influence the concrete workability. Generally, a water cement ratio of 0.45 to 0.6 is used for good workable concrete without the use of any admixture. Higher the water/cement ratio, higher will be the water content per volume of concrete and concrete will be more workable.

Higher water/cement ratio is generally used for manual concrete mixing to make the mixing process easier. For machine mixing, the water/cement ratio can be reduced. These generalized method of using water content per volume of concrete is used only for nominal mixes. For designed mix concrete, the strength and durability of concrete is of utmost importance and hence water cement ratio is mentioned with the design. Generally designed concrete uses low water/cement ratio so thatdesired strength and durability of concrete can be achieved.

**4. Mix Proportions of Concrete**

Mix proportion of concrete tells us the ratio of fine aggregates and coarse aggregates w.r.t. cement quantity. This can also be called as the aggregate cement ratio of concrete. The more cement is used, concrete becomes richer and aggregates will have proper lubrications for easy mobility or flow of aggregates. The low quantity of cement w.r.t. aggregates will make the less paste available for aggregates and mobility of aggregates is restra

## 3rd CHAPTER
## AGREGATE, WATER & ADMIXTUER

1. **Size of aggregate**

Surface area of aggregates depends on the size of aggregates. For a unit volume of aggregates with large size, the surface area is less compared to same volume of aggregates with small sizes When the surface area increases, the requirement of cement quantity also increases to cover up the entire surface of aggregates with paste. This will make more use of water to lubricate each aggregate.

Hence, lower sizes of aggregates with same water content are less workable than the large sizeaggregates.

**2. Shape of Aggregates**

The shape of aggregates affects the workability of concrete. It is easy to understand that rounded aggregates will be easy to mix than elongated, angular and flaky aggregates due to less frictional resistance. Other than that, the round aggregates also have less surface area compared to elongated or irregular shaped aggregates. This will make less requirement of water for same workability of concrete. This is why river sands are commonly preferred for concrete as they are rounded in shape.

**3. Grading of Aggregates**

Grading of aggregates have the maximum effect on the workability of concrete. A well graded aggregates have all sizes in required percentages. This helps in reducing the voids in a given volume of aggregates. The less volume of voids makes the cement paste available for aggregate surfaces to provide better lubrication to the aggregates. With less volume of voids, the aggregate particles slide past each other and less compacting effort isrequired for proper consolidation of aggregates. Thus, low water cement ratio is sufficient for properly graded aggregates.

**4. Surface Texture of Aggregates**

Surface texture such as rough surface and smooth surface of aggregates affects the workability of concrete in the same way as the shape of aggregates. With rough texture of aggregates, the surface area is more than the aggregates of same volume with smooth texture. Thus, concrete with smooth surfaces are more workable than with rough textured

aggregates.

**5. Use of Admixtures in Concrete**

There are many types of admixtures used in concrete for enhancing its properties. There are some workability enhancer admixtures such as plasticizers and superplasticizers which increases the workability of concrete even with low water/cement ratio. They are also called as water reducing concrete admixtures. They reduce the quantity of water required for same value of slump. Air entraining concrete admixtures are used in concrete to increase its workability. This admixture reduces the friction between aggregates by the use of small lair bubbles which acts as the ball bearings between the aggregate particles.

**Measurement of Workability:**

**Slump Test.**

Concrete slump test is to determine the workability or consistency of concrete mix prepared at the laboratory or the construction site during the progress of the work. Concrete slump test is carried out from batch to batch to check the uniform quality of concrete during construction. The slump test is the simplest workability test for concrete, involves low cost and provides immediate results. Due to this fact, it has been widely used for workability tests since 1922. The slump is carried out as per procedures mentioned in **IS 456: 2000** Generally **concrete slump value** is used to find the workability, which indicates water-cement ratio, but there are various factors including properties of materials, mixing methods, dosage, admixtures etc. also affect the concrete slump value.

**Factors which influence the concrete slump test:**

-Material properties like chemistry, fineness, particle size distribution, moisture content and temperature of cementitious materials.

- Size, texture, combined grading, cleanliness and moisture content of the aggregates,

-Chemical admixtures dosage, type, combination, interaction, sequence of addition and itseffectiveness,

-Air content of concrete,

-Concrete batching, mixing and transporting methods and equipment,

-Temperature of the concrete,

Sampling of concrete, slump-testing technique and the condition of test equipment,

-The amount of free water in the concrete, and

-Time since mixing of concrete at the time of testing.

**Equipment's Required for Concrete Slump Test:**

Mould for slump test, non-porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end.

**Sampling of Materials for Slump Test:**

A concrete mix (M15 or other) by weight with suitable water/ cement ratio is prepaid in the laboratory similar to that explained in 5.9 and required for casting 6 cubes after conducting Slump test.

**1. Compaction Factor Test**

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete. The compaction factor test is used for concrete which have low workability for which slump test is not suitable.

**Apparatus**

Compaction factor apparatus consists of trowels, hand scoop (15.2 cm long), a rod of steel or other suitable material (1.6 cm diameter, 61 cm long rounded at one end) and a balance.

**Sampling**

Concrete mix is prepared as per mix design in the laboratory.

**Procedure of Compaction Factor Test on Concrete**

-Place the concrete sample gently in the upper hopper to its brim using the hand scoop and level it.

-Cover the cylinder.

-Open the trapdoor at the bottom of the upper hopper so that concrete fall into the lower hopper. Push the concrete sticking on its sides gently with the road.

-Open the trapdoor of the lower hopper and allow the concrete to fall into the cylinder below.

-Cut of the excess of concrete above the top level of cylinder using trowels and level it.

-Clean the outside of the cylinder.

-Weight the cylinder with concrete to the nearest 10 g. This weight is known as the weight of partially compacted concrete (W1).

-Empty the cylinder and then refill it with the same concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to obtain full compaction.

-Level the top surface.

-Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (W2).

-Find the weight of empty cylinder (W).

**2. VEE-BEE CONSISTOMETER TEST**

**SUITABILITY**

This method is suitable for dry concrete having very low workability

**PROCEDURE**

The test is performed as given described below

1. Mix the dry ingredients of the concrete thoroughly till a uniform colour is obtained and then add the required quantity of water.

**2. Pour the concrete into the slump cone with the help of the funnel fitted to the stand.**

**3. Remove the slump mould and rotate the stand so that transparent disc touches the top of the concrete.**

**4. Start the vibrator on which cylindrical container is placed.**

**5. Due to vibrating action, the concrete starts re-moulding and occupying the cylindrical container.**

**Continue vibrating**

**the cylinder till concrete surface becomes horizontal.**

**6. The time required for complete remoulding in seconds is the required measure of the workability and it is expressed as number of Vee-bee seconds.**

**COMPARISON OF WORKABILITY MEASUREMENTS BY VARIOUS METHODS**

| Workability Description | Slump in mm | Vee-bee Time in Seconds | Compacting Factor |
|---|---|---|---|
| Extremely dry | – | 32 – 18 | |
| Very stiff | – | 18 – 10 | 0.70 |
| Stiff | 0 – 25 | 10 – 5 | 0.75 |
| Stiff plastic | 25 – 50 | 5 – 3 | 0.85 |
| Plastic | 75 – 100 | 3 – 0 | 0.90 |
| Flowing | 150 – 175 | – | 0.95 |